

STUDY ON THE LEVEL OF SULPHATES, PHOSPHATES, AND NITRATES IN WATER AND AQUEOUS SEDIMENTS OF LAKE CHAD BASIN AREA OF BORNO STATE, NIGERIA

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ABSTRACT

Aqueous water and sediment samples from six (6) sampling points of lake Chad area were collected and analyzed for sulphates, phosphate and nitrate levels. Determinations were conducted by titrimetry, Brucine and Ammonium molybdo-vandate methods, respectively. The samples were ashed and digested by standard methods before final analysis. Results show variation in concentration of ions with respect to season and location. Higher Sulphate concentration ($2620 \pm 5.65 \mu\text{g/g}$) was observed in Wulgo (wet season); while highest Phosphate of $1325 \pm 8.00 \mu\text{g/s}$ (dry season); and higher Nitrates of ($3151 \pm 44.75 \mu\text{g/g}$) was equally observed in Dan Baure in dry season. The variation was statistically significant ($P \leq 0.05$). Thus, Dan Baure sediments was found to have higher deposition of Phosphate and Nitrate which might be due to high fishing and agricultural activities over long period of time as evident by the high population of fishing and farming in the area.

KEYWORDS: Surface water, Aqueous sediments, Eutrophication, Lake Chad, Titrimetry, Borno

INTRODUCTION

The applications of fertilizers and other particles and insecticides over a long period of time in agricultural areas have generated a lot of concern to scientist. Deposition of suspended solids in stretches of stream will impair the normal aquatic life of a stream (Chatwal, *et al*, 1990). A number of factors are responsible for the dispersion of pollutants between the phases of an aquatic system such as the chemical nature of the pollutant species, which is mainly associated with its affinity for dissolution in water phase or its affinity for sediments sorption. Studies of sediment-water partitioning of pollutants in aquatic environment have been well documented (Manahan, 2005; Brydie and Polya 2003).

The source of pollution comes either by point source or non-point source. Thus, human activities, surface run-off, acidic deposition on lakes, rivers and oceans, volcanic activities as well as agricultural process could generate pollutants into streams, lakes oceans and rivers (Chapman 1996).

Lake Chad has a water surface area exposure, fluctuating in size between 25,000 and 15,000km² and up to 2,000km² during severe drought. This corresponds to a water volume of $20-100 \times 10^9 \text{m}^3$. The average water depth is 2m, with depth of as much as 7m in the northern part of the basin and 11-12m in the southern part (SATTEC, 1992). The higher water level of the lake in recent times is 283m above msl (Durand, 1995).

Contaminations of streams by metals is a major phenomena especially in drier parts of the world, though scarcely toxic, it is readily reduced to nitrites which is poisonous at concentrations exceeding 10mg/l. Nitrite fertilizers are possible source of contaminations as the ion is high in the soil (Margaleef, 1996). Nitrogenous form of fertilizers such as urea and ammonia can be converted to nitrate quite rapidly by soil bacteria. Thus, nitrates together with phosphate are the major cause of eutrophication in lakes (Hill, 1984; Kakulu and Osibanjo, 1988).

Eutrophication refers to the excessive fertilizing by nutrients (primarily phosphorus and nitrogen compounds) of lakes, reservoirs, slow-flowing rivers and certain marine coastal waters which results in the nuisance growth of aquatic plant materials, such as algae and macrophytes {USEPA, (1999), APHA, (1992); Quinby-Hunt *et al.*, (1986)}. The unsaturated zone sediments are sandy and unconsolidated with high permeability, although low conductivity clayey sand and clay horizons have been encountered in some of the profile, hampering movements of soil water (Edmunds, *et al*, 1998). The storage and transport capacity of the study area can easily be visualized from

the unsaturated zone moisture profile; where high moisture in clays corresponds to high storage and low moisture contents in sands relates to high transport capacity (Goni, and Edmund, W.M; 2001). Anaerobic conditions of sediments are accompanied by the release of phosphate to the water column. Also, due to the reduction of iron and sulphate formation, the solubility of phosphate and the recycling is increased. In many cases, the release of phosphate from the sediments coincides with a reversal of stratified zones due to temperature (Oteze and Fayose, 1988).

MATERIALS AND METHODS

Sample and sample preparation

Aqueous water and sediment samples were collected in a pre cleaned plastic container by scooping methods. Samples were collected from six (6) sampling points (Fig. 1) between March-April (dry season) and August-October (wet season), respectively. Samples were kept in a refrigerator at 4°C for preservation.

The sediment samples (3g) were placed in crucibles and oven-dried at 50°C to constant weight. The samples were then homogenized as much as practicable using agate mortar and pestle and then stoned in acidified polythene container and labeled. 0.3g of the dried and pulverized sediment sample was weighed into a platinum crucible and 5 drops of deionized water were added to dampen the sample.

METHODOLOGY

Determination of sulphate (SO_4^{2-})

Gravimetric method was used. 100 ml of the water sample were taken and filtered. 1: 1 v/v HCl was added in drops until acid to litmus, three drops was added in excess and the solution evaporated to 50 ml. The solution was boiled and the boiling BaCl_2 solution was added until all the sulphate was precipitated. The precipitate was allowed to settle by digesting in a water bath. The precipitate was filtered through a sintered glass crucible (already dried to constant weight). The precipitate was then oven dried at 105°C to constant weight and sulphate was determined using the equation below.

$$\text{SO}_4^{2-} (\text{mg/l}) = \frac{\text{mgBaSO}_4 \times M}{\text{ml Sample}}$$

Where:

mg BaSO_4	=	weight of BaSO_4 in milligrams
ml sample	=	volume of sample taken for evaporation
M	=	411.5

Determination of phosphate (PO_4^{3-} - P)

Ammonium molybdo-vanadate method was used. 50cm³ of the water sample was filtered using filter paper and transferred into a flask. 25cm³ of ammonium molybdo-vanadate solution were added to the sample and mixed thoroughly. This mixture was allowed to stand for 5 minutes for color development (yellow). This procedure was carried out using only distilled water, which was to serve as blank solution intended for use as reference sample.

The absorbance of the sample solution was measured using Cecil (CE) 7200, Model; spectrophotometer at a wavelength of 400nm. This was conducted first, by introducing the blank solution into the sample cell and the cells were replaced onto their compartment. This was followed by selecting the wavelength (nm) and zeroing the absorbance of the blank. This was immediately followed by the introduction of the sample solution and reading the absorbance values. The concentration of orthophosphate of the water sample was calculated using the following expression (ASTM, 1980).

$$\text{PO}_4^{3-} (\text{mg/l}) = A \times \text{calibration factor}$$

Where: A = Absorbance

Determination of Nitrate (NO_3^- - N) Brucine Method

Brucine Method was used. To obtain a calibration curve, standard solutions of various concentrations were prepared from the nitrate stock solution.

A number of beakers were arranged in a row. The first five (beakers) contained 10cm³ of each of standards in an increasing order. These were followed by the samples each containing 10cm³ of the water samples. 1cm³ of Brucine – sulphanilic acid reagent was added into each of the standard solutions and the samples. The resultant mixtures were mixed thoroughly and allowed for 15 minutes. 10 cm³ of H₂SO₄ solution were carefully added to 10 cm³ of distilled water and the resulting solution was added to each of the beakers containing both the standard nitrates solutions and the water samples. This was allowed to stand for 20 min in the dark.

Similar treatment was performed on the blank solution except that no Brucine sulphanilic reagent was added to it. The blank solution was used to zero the absorbance of the double beam spectrophotometer Cecil (CE) 7100 model before the absorbencies of the standards and samples were determined at 410 nm wavelength using a DR2000 UV/Visible spectrophotometer. The resultant absorbance values were then plotted against the corresponding concentrations of nitrate standard solutions. The actual concentrations were obtained on the calibration curve by extrapolation. (ASTM, 1980).

RESULTS

DISCUSSION

Tables 1 and 2 represent the mean concentration levels of sulphate, phosphate and nitrates in some portions of Lake Chad area, Borno state. From this study, it was observed that there was variation in concentration with respect to season and location. The values were statistically significant at $P \leq 0.05$. It is evident that Kirenowa has the highest sulphate level of $5885 \pm 13.23 \text{ mg/g}$; Dan Baure has the highest phosphate level of $13.25 \pm 8.0 \text{ mg/g}$ while the highest nitrate level of $5835 \pm 6.30 \text{ mg/g}$ was observed in Marte sediments respectively.

High sulphate levels were observed in Kirenowa. Sulphates naturally occur in surface water which arises from the leaching of sulphur compounds either as sulphate minerals such as gypsum or sulphite as pyrite or from sedimentary rocks. Also, the variation in concentration of sulphate at different locations could be due to the fact that the sulphate discharged to the lakes was used up as a source of oxygen by bacteria and was converted entirely to H₂S under anaerobic conditions. Phosphate and nitrate levels were a measure of level of eutrophication of a given lake. The high concentration of phosphate in Dan Baure and nitrates in Marte suggest areas to have more aquatic and agricultural activities. Thus, natural process, human and animal

activities as well as fertilizer run-offs into rivers could influence plant growth and decay. The use of detergents and other addition in fishing environment could increase the level of phosphate which will be sorbed to the bottom of the river and settle down (sediments). The rate of mobility of ions based on their size and stability could also dictate the residual time in water before reaching the bottom of the lake.

In conclusion, the sediments of the lake had high values of sulphate, phosphates and nitrates. The concentration varies with season and location with higher values during rainy (wet) season. However, further monitoring studies are needed to assess the levels of pollution of the lake in terms of heavy metals, organic pollution indication and certain biological processes.

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Table 1 Mean concentration of Sulphates, Phosphates and Nitrates (mg/l) of surface water samples obtained from Lake Chad basin area, Borno state, Nigeria

LOCATION	Sulphates			Phosphates			Nitrates		
	SEASONAL MEAN CONCENTRATION ± SD								
	DRY March – April	WET July – September	X ± SD Overall average	DRY March – April	WET July – September	X ± SD Overall average	DRY March – April	WET July – September	X ± SD Overall average
Baga	08.47 ± 0.34	05.13 ± 0.15	06.80 ^d ± 0.29	1.09 ± 0.12	1.83 ± 0.10	1.46 ^c ± 0.11	2.36 ± 0.18	9.88 ± 0.41	6.12 ^{de} ± 0.29
Marte	06.00 ± 0.29	17.87 ± 3.07	11.94 ^b ± 1.68	2.45 ± 0.09	1.30 ± 0.08	1.88 ^a ± 0.08	12.13 ± 1.93	6.08 ± 0.38	9.10 ^c ± 1.16
Dan Baure	07.25 ± 0.41	05.23 ± 0.05	06.24 ^d ± 0.23	3.46 ± 0.06	1.83 ± 0.05	2.65 ^a ± 0.06	7.28 ± 0.71	6.03 ± 0.16	6.65 ^d ± 0.49
Kirenowa	07.83 ± 0.47	20.25 ± 0.50	14.04 ^a ± 0.49	0.99 ± 0.05	1.19 ± 0.06	1.09 ^d ± 0.06	3.38 ± 0.82	26.25 ± 1.26	14.81 ^b ± 1.04
Wulgo	09.48 ± 0.32	09.63 ± 1.11	09.55 ^c ± 0.72	1.23 ± 0.06	1.93 ± 0.07	1.58 ^c ± 0.07	3.78 ± 0.69	5.03 ± 1.18	4.40 ^e ± 0.94
Monguno	07.25 ± 0.25	15.08 ± 1.25	11.16 ^{bc} ± 0.75	1.43 ± 0.03	2.70 ± 0.04	2.06 ^b ± 0.04	3.03 ± 0.12	32.50 ± 5.83	17.76 ^a ± 3.03
Seasonal average	7.71 ± 0.35	12.19 ± 1.02	9.96 ± 0.69	1.78 ± 0.07	1.79 ± 0.06	1.79 ± 0.07	5.33 ± 0.74	14.29 ± 1.54	9.81 ± 1.16

Mean with different letters are significantly different by Duncan multiple range test at 5%.

Table2. Mean concentration of Sulphates, Phosphates and Nitrates ($\mu\text{g/g}$) of sediment samples obtained from Lake Chad basin area, Borno state, Nigeria

LOCATION	Sulphates			Phosphates			Nitrates		
	SEASONAL MEAN CONCENTRATION ± SD								
	DRY March – April	WET July – September	X ± SD Overall average	DRY March - April	WET July - September	X ± SD Overall average	DRY March – April	WET July - September	X ± SD Overall average
Baga	1068.3±27.53	1250±25.00	1159.2 ^b ±26.27	130.0±1.00	320±20.5	225 ^b ±15.25	537.7±10.78	536.0±33.50	536.9 ^c ±22.14
Marte	5810±65.57	5163±40.50	5486 ^a ±53.04	129.0±6.08	230±8.5	179.5 ^b ±729	627.7±2.89	5835.0±26.30	232 ^a ±14.59
Dan Baure	127.7±2.53	582.0±16.30	354.9 ^c ±9.41	1132.7±7.51	1325±8.0	1228.9 ^a ±7.76	3151.3±44.75	128.0±3.50	1639.5 ^b ±24.13
Kirenowa	5885±13.23	5325±20.50	5605 ^a ±16.62	117.5±6.61	2215±7.5	1166.3 ^a ±7.06	188.8±1.53	336.0±28.50	262 ^d ±15.02
Wulgo	1251.6±2.89	2620±5.65	1935.5 ^b ±4.27	37.67±2.75	45.0±3.5	41.34 ^c ±3.13	255.0±5.15	133.0±30.50	194 ^d ±17.83
Monguno	625.3±3.50	530±5.20	577.7±4.35 ^c	120.5±3.50	200±2.0	160.3 ^b ±2.75	582.3±2.35	623.0±20.20	602.7±11.28 ^c
Seasonal average	2461.3 ± 19.21	2578.3 ± 18.86	1594.9 ± 8.99	277.8 ± 4.58	722.5 ± 8.33	500.2 ± 7.21	890.47 ±11.24	1265.2 ± 3.75	926.02 ± 17.49

Mean with different letters are significantly different by Duncan multiple range test at 5%.